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Haystack Pointing System: Digital Equipment Organization

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LINCOLN LABORATORY

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P. D. SMITH

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ABSTRACT

This report describes the operation and organization of the digital equipment associated with the Univac 490 pointing computer at Haystack. All of the input/output equipment connected to the U490 is discussed with the major emphasis being placed on that equipment associated with pointing the antenna.

Accepted for the Air Force
Franklin C. Hudson
Chief, Lincoln Laboratory Office

HAYSTACK POINTING SYSTEM: DIGITAL EQUIPMENT ORGANIZATION

I. INTRODUCTION

A. General

The focal point for the discussion of the digital equipment associated with pointing the Haystack antenna will be the Univac 490 computer. The primary function of the computer is the pointing of this antenna. However, it can also be used for data recording, data processing, generation of equipment control signals, and pointing the Millstone and West Ford antennas. The major part of this report will deal with the subsystems connected with pointing the Haystack antenna, but a limited discussion of all of the subsystems connected to the computer will be included.

A general block diagram of the Univac 490 computer and its associated input/output subsystems is shown in Fig. 1. This diagram includes some of the auxiliary instrumentation associated with the radar systems which will be used on the Haystack antenna. Those blocks labeled SEQUENTIAL DATA PROCESSOR and RANGE ENCODER AND TRACKER, fall into this category. They were included to show the connections from the computer to a typical radar system. The radiometer system was also included and as shown it ties into the computer through the input and output signal interfaces on channel 5. As shown there are fourteen input and fourteen output channels on the computer. Channels zero and one were designed for computer to computer communication and are slightly different from the other twelve channels. However, they can be used for other types of input/output connections as has been done with the Remote Teletype Console subsystem. For a detailed discussion of the input/output system see Univac 490 Central Computer Service Manual, PX 2122, Volume II, Part 2, Principles of Operation.

This report will not give any detailed information on the standard Univac peripheral systems which are connected to the computer. This includes the Uniservo Magnetic Tape subsystem connected to channel 13, the Paper Tape Subsystem connected to channel 4, the Univac 1004 III System connected to channel 3 and the Computer Consoles connected to channel 2.

B. System Operation

An operator controls the pointing system from the Computer Console and the Pointing Console which are located in the center of the control room at Haystack. The Computer Console contains a keyboard and printer for communication with the computer. The Pointing Console presently being used* contains mode selection switches, handwheels for manual control, a general purpose oscilloscope, and Nixie displays of azimuth and elevation antenna command, antenna position, antenna bias, and right ascension, declination, local hour angle and Greenwich mean time.

The control systems for the azimuth and elevation axis are independent in operation. For this reason two independent sets of mode switches are included on the Pointing Console. These allow the selection of one of the following modes of operation for each of the axis: Computer Digital; Manual Digital; Manual Scan; Manual Synchro; or Auto Track.

The primary mode of operation is Computer Digital. When in this mode the computer generates pointing angles for the antenna. Manual biases can be superimposed on the computer outputs by the use of handwheels located on the Pointing Console. This enables an operator to make manual corrections of the pointing angles generated by the computer or to do manual scans about a computed position. The total bias entered with each handwheel is shown in a corresponding Nixie display for that axis. An extensive software system has been written for the computer which allows an operator to select many different modes of tracking and scanning. The selection of these modes is made by an operator from a Computer Console. For example, an operator can select to track the moon, sun, planets, one of a number of stars or an artificial earth satellite just by typing in the name of the object and in some cases answering a few questions about parameters not stored in the computer. Antenna scans and search patterns can also be selected by typing in the necessary parameters such as limits and rates. This is a very powerful system which because of its ease of operation will allow very precise control of the antenna by operators who are relatively unfamiliar with antenna pointing systems.

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*A more elaborate Pointing Console which will replace the one now being used is under construction.

In the Manual Digital mode of operation the antenna is pointed manually with the handwheels on the Pointing Console. The command angles to the servo and the position angles from the antenna are displayed on the console in Nixie lights.

In the Manual Scan mode of operation the handwheels will be used to select a center position for the antenna about which a scan will be performed. The amplitude and rate of the scan will be selected with controls* on the console. Displays of Scan Center Command angle, * Antenna Command Angle and Antenna Angle will be presented in Nixies.

In the Manual Synchro mode of operation the handwheels on the console are connected to synchros which in conjunction with synchros on the antenna mount develop the error voltages to drive the servos. It is not expected that this mode of operation will be used during experiments except in the event of a failure in the digital system.

In the Auto Track mode of operation two types of tracking loops may be used. One is a tracking loop which is closed directly through the servo system. With this loop the antenna is entirely under the control of the tracker. The other is a tracking loop which is closed through the computer. With this loop the operation will be the same as in the Computer Digital mode, except that the computer will be using the tracker error values in generating new pointing angles.

Range and doppler predictions are calculated by the computer and if desired, these can be furnished to the operating radar system. The doppler input/output is on channel 9 and the range input/output is on channel 8. The input channels are used for the input of radar measured doppler and range when these are available. The radar return signal parameters can be brought into the computer on channel 5. Both analog and digital data is accepted by the equipment on this input channel. If requested the computer will record on magnetic tape the command and antenna pointing angles, predicted and radar measured doppler and range, monopulse tracking errors, and system operating mode information.

When the computer is used in conjunction with a radiometer experiment, the range and doppler channels are not used. For these experiments the general purpose

*Not included in the present console.

input equipment on channel 5 is disconnected and the radiometer data handling system is substituted. When operating with the radiometer the computer can be used for pointing and for real-time processing and recording of the input data from this system. The general purpose output equipment on channel 5 may be used for generating control signals for the Radiometer Control and Data Handling Equipment. This output is also used to drive the Right Ascension, Declination and Local Hour Angle Nixie displays.

The intersite coupling channel connects the computer to the Millstone and West Ford antenna systems. The West Ford coupling allows the computer to send pointing angles and range and doppler values to the West Ford site. With this coupling the West Ford antenna system can utilize the very powerful and versatile computer pointing system at Haystack.

The Millstone coupling allows the computer at Haystack to send pointing angles and range and doppler values to Millstone and to receive from Millstone antenna pointing angles, monopulse error values, range and doppler values, time, and target return amplitude. This coupling will allow the Millstone antenna system to utilize the computer pointing system at Haystack and it will also allow the Haystack antenna to be slaved to the one at Millstone. Because of its wider beamwidth the Millstone antenna will be able to acquire certain types of targets easier than the Haystack antenna. For these targets it may prove to be desirable for acquisition to slave the Haystack antenna to the one at Millstone.

In conjunction with the Intersite Couplings a Remote Teletype Console subsystem has been connected to the computer. This allows the computer pointing system to be operated from either the West Ford or the Millstone sites. Thus, when the antennas at these sites are being controlled by the Haystack computer the person operating the pointing system can be located at the site where the experiment is being performed.

The pointing system for the Haystack computer operates in real time and to generate accurate control data it must know the time very accurately. To furnish this information the time from the station clock is made available to the system on input channel 7. It is not necessary for the pointing system to continuously read the clock because the output requests on the azimuth and elevation channels are also tied to the station clock and occur at a rate of 250 times per second. Once the system reads the clock and synchronizes itself with real time, it is then locked to real time with the output transfers on the azimuth channel.

In the following sections of this report the operation and organization of the individual units of digital equipment associated with the Haystack pointing system will be discussed.

II. DIGITAL EQUIPMENT ORGANIZATION

A. Azimuth and Elevation

The azimuth and elevation control systems are essentially identical in organization and operation except for the limits of travel. The elevation travel is limited to approximately 92.5 degrees whereas the azimuth travel is limited by the cable wrap design to approximately 600 degrees. For this reason, the azimuth control system is slightly more complex in that, in addition to the angle, a zone must also be defined to specify the position within the 600 degree limit. The zone is specified by a single bit called the overlap bit.

The major units which are associated with the Haystack antenna pointing are shown as blocks in Fig. 1 and these include the Control Generators, the Buffer Translators, the Comparators, the D/A Convertors, the Servos, the Encoders, the Synchros, the Analog Monopulse Tracker, the Display Translator and the Pointing Console. The following is a discussion of the operation and organization of each of these units.

The azimuth and elevation Interfaces contain the circuitry necessary for electrically matching the external equipment to the input and output channels on the Univac 490 computer. They also include data bit storage and some control logic on the input channels. The input angle data to the computer is generated by the angle encoder subsystems which were built by Telecomputing Corporation, La Mesa, California. The output angle data from the computer goes through the Interfaces to the azimuth and elevation Control Generators which were built by Computer Control Company, Framingham, Massachusetts, using their S-PAC digital modules.

The Control Generators contain the circuitry for adding bias to computer generated pointing angles, for manual digital control of the antenna and for generating antenna scans. There are three modes of operation of these units, Computer, Manual and Scan. The control signals for mode selection come from the Pointing Console.

When the system is operating in the Computer Digital pointing mode the Control Generator will be operating in the Computer mode. In this mode pointing command angles will be requested from the computer at a rate of 250 per second and manual bias will be added onto these angles. The manual bias is generated in the Control Generator by counting the pulses from an incremental encoder within the unit. This encoder is driven by an instrument servo system connected to a handwheel on the Pointing Console. This system is bidirectional throughout so that bias can be increased or decreased with both positive and negative accumulations possible. After the addition of the bias the angles are passed on to the Buffer Translator. For the elevation channel the angle inputs and outputs are 19 bits and for the azimuth channel an additional bit specifying the overlap is included. When the system is operating in the Manual Digital pointing mode the Control Generator will be operating in the Digital mode. The outputs from the computer will continue, but they will not be used. When the Control Generator is switched into this mode the pointing angle of the antenna, as measured by the encoder system, will be loaded into a register. The angle stored in this register can then be increased or decreased by the output of the same incremental encoder that is used in bias generation. The contents of this register are output to the Buffer Translator at a rate of 250 times per second and are used for pointing the antenna. When the system is operating in the Manual Scan mode the Control Generator will be operating in the Scan mode. The operation of the Control Generator in this mode is the same as in the Manual Digital mode except that a scan is superimposed on the angle before it is sent to the Buffer Translator. When the pointing system is operating in the Manual Synchro or Auto Track Pointing mode the Control Generator will be in the Computer mode.

The primary function of the Buffer Translators is to store the command angles from the Control Generator until they can be used by the Comparators in the servo system. These units also provide decimal displays of the command angles and binary displays of both the command and antenna angles. Digital command angles can be generated with push buttons on these units and a local mode of control can be selected. When this is done the digital command angles from the Control Generators are not used and instead the locally generated command angles are used as outputs to the servo system.

Digital outputs of the command, antenna and bias angles are sent to the Display Translator from the Buffer Translator. The Display Translator also has a binary coded decimal, BCD, input of Eastern Standard Time, EST, from the station clock. The function of the Display Translator is to drive Nixie displays of times; EST and GMT, and angles; command, antenna and bias. The Nixie driver circuits require BCD inputs of the data. The EST from the clock is in this form and the GMT is derived from EST by a logic net, the output of which is in BCD form. The angle inputs to the Display Translators are expressed as 19-bit binary coded parts of a circle with an additional bit included with the bias angles to specify the sign. The Display Translator first converts this to binary coded degrees and finally to BCD degrees. The Nixie driver outputs from the Display Translator are used to drive Nixie displays on the Pointing Console and above the Computer Console which is located by the computer. These outputs can also be used to drive additional displays which may be installed at other locations around the site. For a complete description of the Display Translator see: S. B. Russell, "Haystack Display Translator," Lincoln Laboratory Technical Note 1966-24.

The Comparators have inputs of command angles from the Buffer Translators and antenna angles from the Encoders. These units compare these inputs and produce a signed digital output of pointing error. The Comparators and Encoders operate at a rate of about 305 operations per second. The antenna position is measured at this rate and the angle error values are updated at this rate. The error values from the Comparators feed into D/A (Digital to Analog) Converters which convert these digital signals into 400-cycle analog signals suitable for driving the Servo systems. The switches shown in Fig. 1 between the D/A Converters and the Servos were included to indicate the different sources of signals available to drive the Servo systems. The selected source for each axis is determined by the pointing mode selected for that axis. As shown,the servos can be driven by Synchro systems and the Analog Monopulse Tracker system as well as the digital systems.

Two tracking subsystems have been built for the Haystack pointing system. The Analog Monopulse Tracker shown on the block diagram (Fig. 1) will operate with the two millisecond pulse radar system, which includes the Sequential Data Processor and the Range Encoder and Tracker. These units have been built but not yet integrated into

the Haystack system. The other tracker is a passive tracker which generates error values from the signal received from a beacon transmitter. This unit has been integrated into the Haystack system.

The Analog Monopulse Tracker has provisions for both analog and digital outputs of the azimuth and elevation error values. The analog outputs could be used for closing the tracking loop directly through the servo and the digital outputs could be used for closing the control loop through the computer or for recording tracking errors. It is not clear at this time which way the loop will be closed with this tracker.

The passive tracker has digital outputs of the error values which are input to the computer, the azimuth through the interface on channel 11, and the elevation through the interface on channel 10. Using these error values the computer generates the digital command angles for the antenna. Closing the control loop through the computer, as has been done with this tracker, allows the tracking characteristics of the system to be controlled and changed by the computer.

The Haystack Pointing Console along with its associated Computer Console have on them the necessary displays and controls for operation of the pointing system. These two units are located together for use by one operator. A second Computer Console is located in the computer room near the computer maintenance panel. The Computer Consoles each include a printer for output from the computer and a keyboard for input to the computer. Both an input and an output channel are required for these consoles. A relay is used to select which of the two consoles will be connected to the computer. This relay is controlled by a pair of switches, one located on each console. This allows the selection of the active console to be made at either location. Field Data symbols and codes are used for both the printer and keyboard. For a complete description of the Computer Console see Univac Service Manual, PX2120, Univac 490, Control Console Type 8009. A pointing console to replace the one presently being used is now under construction. The layout of the controls and indicators on this new console is shown in Fig. 2. As shown, the main panel will be functionally divided into two parts. The controls and displays for elevation will be located on the left half and those for azimuth on the right half. The Mode switches which are to be located at the bottom of the panel will be used for selection of the operating mode for that pointing axis. The left most switch will be an on/off alternate action push button switch which will enable the servo and mode select circuitry. All of the switches

will have back-lighted legends in the upper half of the switches to indicate the function of each switch and back-lighted legends in the lower half of the switches to indicate the selected mode.

The set of six switches to be located in the center of the panel above the mode selection switches will be computer input output indicators. The left three will be alternate action switches which will control three input bits to the computer. The right three will be used only as indicator lights controlled by three output bits from the output signal interface on channel 5. The meaning of these input and output bits will not be fixed, but will depend upon the operating mode of the computer.

The action of the handwheels on this panel will depend on the operating mode of the system. In the Computer Digital mode the handwheel will be used for adding a bias onto the computer command angle. The bias added will be shown in the Antenna Bias Nixie display and the sum of the computer command angle and the bias will be shown in the Antenna Command Nixie display. In the Manual Digital mode the handwheel will be used to control the command angles which will be shown in the Antenna Command Nixie display. In the Manual Scan mode, it will be used to control the center of scan angle which will be shown in the Scan Center Command Nixie display. In the Manual Synchro mode the handwheel will drive the synchro in the console, which in conjunction with the synchro on the antenna mount, will generate the error voltage for the servo. A synchro repeater with a dial will be used in the control console to indicate antenna position. These indicators will be located beside the handwheels. The handwheels will perform the same function in the Auto Track mode as in the Computer Digital mode. The vertical row of switches beside the handwheel will control the angular change per handwheel revolution when in a digital mode of control. The minimum value will be 0.038 degrees per revolution with a quantum of 0.0007 degrees and the maximum value will be 9.843 degrees per revolution with a quantum of 0.1758 degrees.

Below the Scan Center Command Nixie displays will be located the controls for selection of scan amplitude and rate for the scan mode. Scan angle amplitudes will be selectable from 0.18 degrees to 92.16 degrees in 10 steps with the amplitude of each step being twice the preceding one. The rate will be continuously variable from Earth rate (0.004 degrees/sec) to beyond the precision rate of the antenna (1 degree/sec).

Antenna Angles for each axis and Right Ascension (RA), Declination (DEC), Local Hour Angle (LHA) and Greenwich Mean Time (GMT) Nixie displays will be included. The computer calculates RA, DEC and LHA and drives these displays through the Output Signal Interface on channel 5.

Displays of the Antenna Status will be located above the Scan Center Command Nixie displays. For azimuth these will indicate antenna zone and travel limits. For elevation they will indicate stow position and travel limits. Analog indicators of the error values generated in the servos will be located between the Antenna Angle and Antenna Command displays. Three switches for turning off the DEC, RA and LHA displays will be located between the DEC and RA displays. An Emergency Off switch will be located in the center of the panel between the mode selection switches. This switch will be used to shut down the antenna drive systems in case of an emergency. The large blank space in the center of the panel will be reserved for a TV Monitor which may be installed in the future.

The controls and indicators for power and antenna servo start-up and monitoring will be located in the vertical section above the main panel. This section will also contain the controls and CRT for a Tektronics model 555 dual-beam oscilloscope. This scope will be used as a general purpose oscilloscope or as a digital plotting scope for computer outputs. When used as a digital plotter, the scope will be driven through the Output Signal Interface on channel 5.

B. Doppler

Channel 9 output and input are used for output of computer-predicted doppler and input of radar-measured doppler. The radars to be used with the Haystack antenna have different requirements for doppler commands and doppler inputs. The Sequential Data Processor, SDP, shown on the block diagram (Fig. 1) will be used with a pulse radar having a 2 ms pulse width. The SDP can automatically doppler track a target or it can use computer predicted doppler for tracking. For each detectable target return it will generate a measured doppler value for input to the computer and for doppler correction in the Analog Monopulse Tracker and it will also generate a pulse which will be used in the Range Encoder and Tracker for range measurement. The SDP will require a 21-bit binary doppler command from the

computer and it will produce a 21-bit binary measured doppler value for input to the computer. It will request a doppler output each main-bang with an external interrupt and the computer will output the information with an external function. A doppler input will be requested by an input data request which will occur after the doppler is measured. This will happen during each main-bang period for which there is a detectable signal return.

The planetary radar to be used with the Haystack antenna requires a doppler output in BCD form. For this output 28-bits are used to give a command doppler range of seven decimal digits. Outputs are requested at a rate of twenty per second using external interrupts and the doppler values are output using external functions. This radar does not use the doppler input channel.

C. Range

The Range Encoder and Tracker will work in conjunction with the SDP to measure and track the range of a target. This unit can automatically range track or it can use computer predicted range values. It will generate a range value for input to the computer and it will also generate a tracking-gate and a false-alarm-gate for use in the SDP and the Analog Monopulse Tracker. The Range Encoder and Tracker will require a 25-bit binary range command from the computer and it will generate a 25-bit range value for input to the computer. It will request a range output each main-bang with an output data request and each time a target is detected the range will be measured and an input will be requested with an external interrupt.

D. Time

The Real Time Clock is driven from the site master oscillator and can be synchronized to real time within $\pm$ 100 microseconds by using a WWV time signal for synchronization. It produces both BCD and binary outputs of time and it has a set of ten outputs which will produce a single pulse at any selected time. The BCD output is used by the Display Translator to drive Nixie displays of GMT and EST. The binary output is input to the computer through the Time Interface on channel 7. The binary time is a 30-bit word with a 100 μs least significant bit. Each time the binary word is updated, the IDR line is set for 60 μs to allow the computer to take the word. If the computer does not take the time word during this interval it must

then wait until the time word is updated 40 μs later. In addition to the binary time input a switch can be set to cause an external interrupt to be generated on channel 7 every second. This interrupt is set on the second and then reset 5 μs later.

E. Intersite Coupling

The Intersite Coupling system provides a connection from the Univac 490 computer at Haystack to the West Ford and Millstone sites. The link to West Ford transmits azimuth, elevation, doppler and range commands to the pointing equipment at that site. These commands are contained in three computer words and the bits are transmitted in serial over phone lines at a 2 kc bit rate. One set of command words is sent every 1/20 of a second. The output to the Millstone pointing equipment consists of four computer words containing azimuth, elevation, range and doppler commands. These commands are transmitted in serial over phone lines at a 3 kc bit rate. One command set is transmitted every 1/20 of a second. The only input from the West Ford site is an external interrupt to indicate a target detection. There are six computer words of input from the Millstone site. These words include the following: target range, target doppler, target detection bit, elevation, elevation monopulse error, azimuth, azimuth monopulse error, time, and target return amplitude from two receivers. The data is transmitted from Millstone to Haystack in serial over phone lines at a 10 kc bit rate. The sets of data words will be transmitted at the Millstone site PRF which will not exceed 30 cps. For a complete description of this subsystem see: A. F. Dockrey, "Haystack Millstone Intersite Coupling," Lincoln Laboratory Technical Note, (to be published) and J. E. Gillis, "Haystack-West Ford Intersite Coupling Link," Lincoln Laboratory Group Report 1964-25, (May 14, 1964).

F. Remote TTY Console

In conjunction with the Intersite Coupling system a Remote TTY Console system was built to allow the pointing program to be controlled from either Millstone or West Ford. This system consists of Teletype Model 28 send/receive sets at each of the two remote sites and control and interface circuitry at the Haystack site. The inputs to the computer are 5-bit Teletype character codes sent from the TTY console keyboards via a phone line. The maximum data rate is ten characters per second. The outputs from the computer are 5-bit Teletype character codes which are sent to

the TTY console printers via a phone line. The maximum data rate is again ten characters per second. Only one of the TTY Consoles can be used for computer input at a time. However, the TTY printers can operate in parallel so that the output from the computer can be monitored at both sites. For a complete description of this subsystem see: P. D. Smith, "Haystack Univac 490 Remote Teletype Console Connection," Lincoln Laboratory Technical Note 1965-17, (May 5, 1965).

G. General Purpose I/O Channel

The General Purpose I/O equipment consists of an Input Signal Interface, ISI, and an Output Signal Interface, OSI, on channel 5. The ISI is used to connect either the radiometer equipment or a general purpose input to the computer. When the radiometer is being used with the antenna the radiometer data will be input to the computer on this channel. When operating with this system the computer is used for data processing and recording of the radiometer data.

The general purpose input includes an A/D converter with 20 addressable analog input channels. This converter generates 15 bits of input data which includes 9 bits plus sign for the quantized analog input and 5 bits to identify the analog input channel. The remaining 15 computer input bits can be used for input of digital signals.

Input data requests are used for input and all 30 data bits are used on this channel. When operating with the radiometer, the radiometer control circuitry generates the input request and when operating with the A/D converter, the converter generates the input request at the completion of a conversion. The converter is triggered by an external signal and can operate at rates up to 2500 conversions per second.

The OSI is a demultiplexer which produces a 26-bit output data word on any one of six output subchannels. The highest order four bits of the computer output word are used for subchannel selection which will permit the expansion of the number of subchannels up to a maximum of sixteen. All computer outputs are via the external function and thus the timing for this channel is determined by the computer program.

Subchannel 1 is a general-purpose subchannel which can be used by the program to generate control or indicator signals for external equipment. When this subchannel is selected by the external function the data bits are stored in a 26-bit register which will remain unchanged until this subchannel is selected again.

Subchannels 2 and 3 are used for BCD outputs of right ascension and declination. Both of these channels have storage and in addition they have BCD to

decimal converts and Nixie drivers. The outputs are used to drive Nixie displays on the pointing console and on the display panel in the computer room.

Subchannel 4 is used as an output to provide control signals to the radiometer equipment. No storage is provided on this subchannel.

Subchannel 5 is used to control a strip chart recorder and the CRT display on the pointing console. Storage is provided which is followed by four 6-bit D/A converts to provide analog signals for 4 channels on the strip chart recorder and two 8-bit D/A converters to provide X and Y deflection signals for a CRT display. One bit of the output word is reserved to control the paper drive motor on the recorder and one bit is reserved to control intensity on the display. The strip chart recorder and the CRT display cannot be used simultaneously.

Subchannel 6 is used for a BCD output of local hour angle. The operation of this subchannel is the same as subchannels 2 and 3. For a complete description of this subsystem see: A. F. Dockrey, J. E. Gillis, and S. B. Russell, "General Purpose I/O Channel and Interface for Haystack U490 Computer," Lincoln Laboratory Technical Note (to be published).

H. Digital Autocorrelator and Digital Plotter

A Digital Autocorrelator is tied to the computer on input channel 6. This subsystem will produce in real time the autocorrelation function of an input signal. The input signal is sampled at a rate of up to 10 mc and the output gives one hundred points on the autocorrelation function. Every 100 ms the Digital Autocorrelator inputs to the computer one hundred 16-bit words from a buffer in the unit. The computer will then integrate the data and perform a Fourier transformation to get a power spectrum. This power spectrum can then be output on a CRT display for use by an operator. It is anticipated that this subsystem will be used in Radio Astronomy for spectral line data and during some radar experiments for doppler radar analysis.

A Calcomp Model 564 Digital Incremental Plotter is tied to the computer on output channel 6. This plotter has a drum which is incrementally rotated to produce X-direction plotting and a carriage with a pen which is incrementally positioned to produce Y-direction plotting. The pen can also be raised and lowered on command from the computer. The size of the increments in both X and Y is 0.005 inch and the speed is 18,000 steps/minute. Plots up to 29-1/2 inches wide and 120 feet long can be produced.

I. Univac Peripheral Systems

Four Uniservo III C magnetic tape drives are connected to the Univac 490 computer at Haystack. These drives are connected to channel 13 of the computer through a Univac III C Control Cabinet. They produce and read magnetic tapes which are compatible with most IBM tape drives. Characters are recorded on tape as seven-bit codes with six bits being used for the character and one bit for parity. Two recording densities are used, either 200 or 556 characters per inch, and the tape speed on these drives is 112.5 inches per second. For a complete discussion of the magnetic tape subsystem see Univac Technical Bulletin: UT3405; Univac 490 Uniservo III C Magnetic Tape Subsystem.

The Univac Paper Tape Subsystem includes a paper tape reader, punch, tape handler and the associated control and interface circuitry. It is connected to the computer on channel 4. The reader is a modified Digitronics B3500 Reader which has a maximum reading rate of 400 characters per second. The punch is a modified Teletype Paper Tape Punch, BRPE-11, which has a maximum rate of 110 characters per second. This subsystem will handle 5, 6, 7, or 8 level tapes. For a complete discussion of this subsystem see Univac Technical Bulletin: UT3413; Univac 490 Paper Tape Subsystem.

The Univac 1004 III system which is connected to the computer on channel 3 includes a processor, high-speed printer, card reader and two Uniservo VI magnetic tape drives. The processor includes a magnetic core memory, of 961 six-bit characters and it can be programmed to perform addition, subtraction, logic, editing and input/output operations. Programs are implemented with patch panel wiring. The high-speed printer has a maximum rate of 600 lines per minute and has 132 print locations. The card reader will read 80 or 90 column cards at a maximum rate of 615 cards per minute. The magnetic tape drives use an IBM compatible format and operate at character densities of 200, 556 or 800 characters per inch. This system can be operated off line independent of the U490 or on line with the U490. For a complete discussion of the Univac 1004 III system see Univac publication: UP3927; General Description Univac 1004 III System.

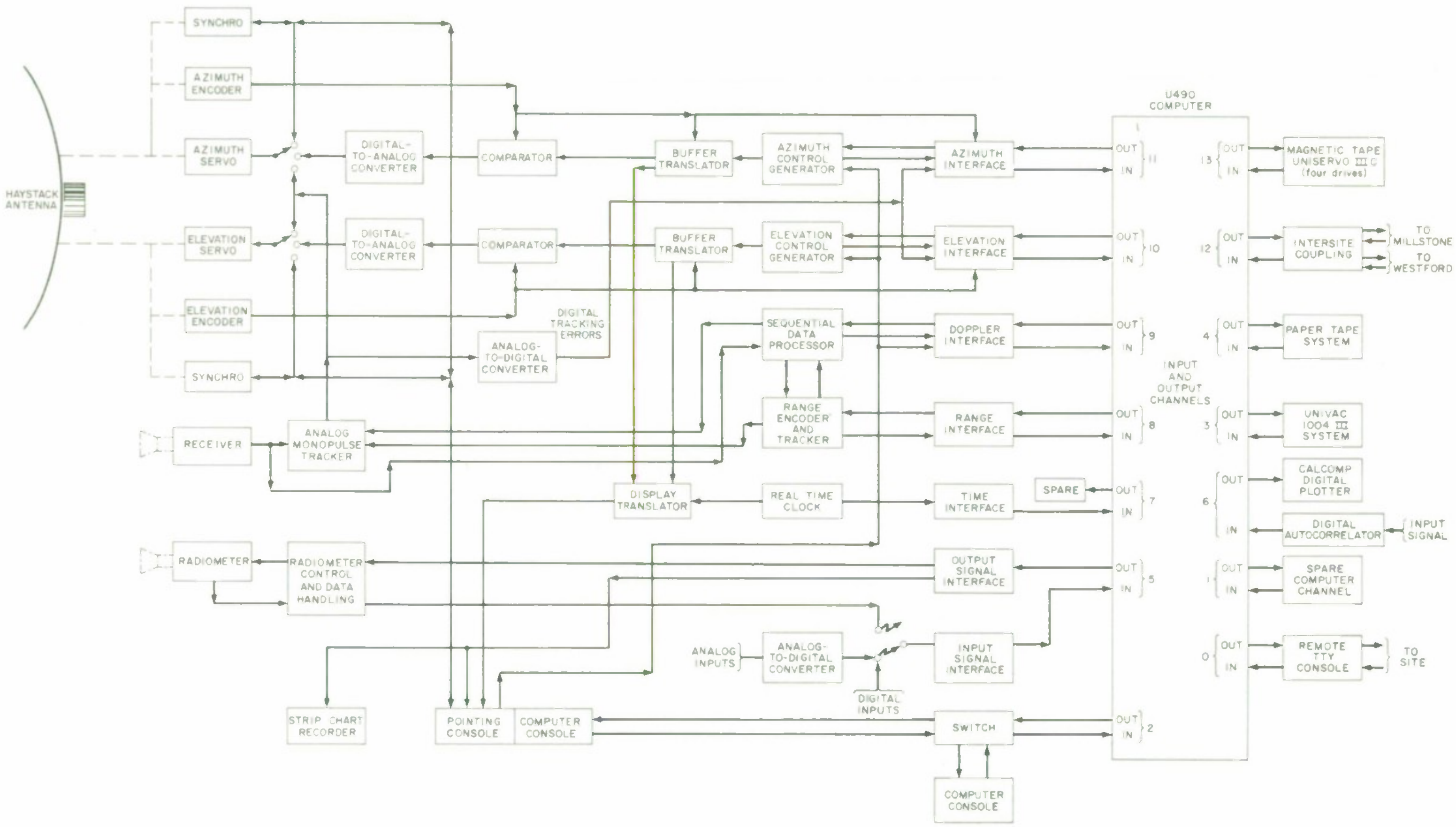

Fig. 1. Haystack antenna pointing system block diagram.

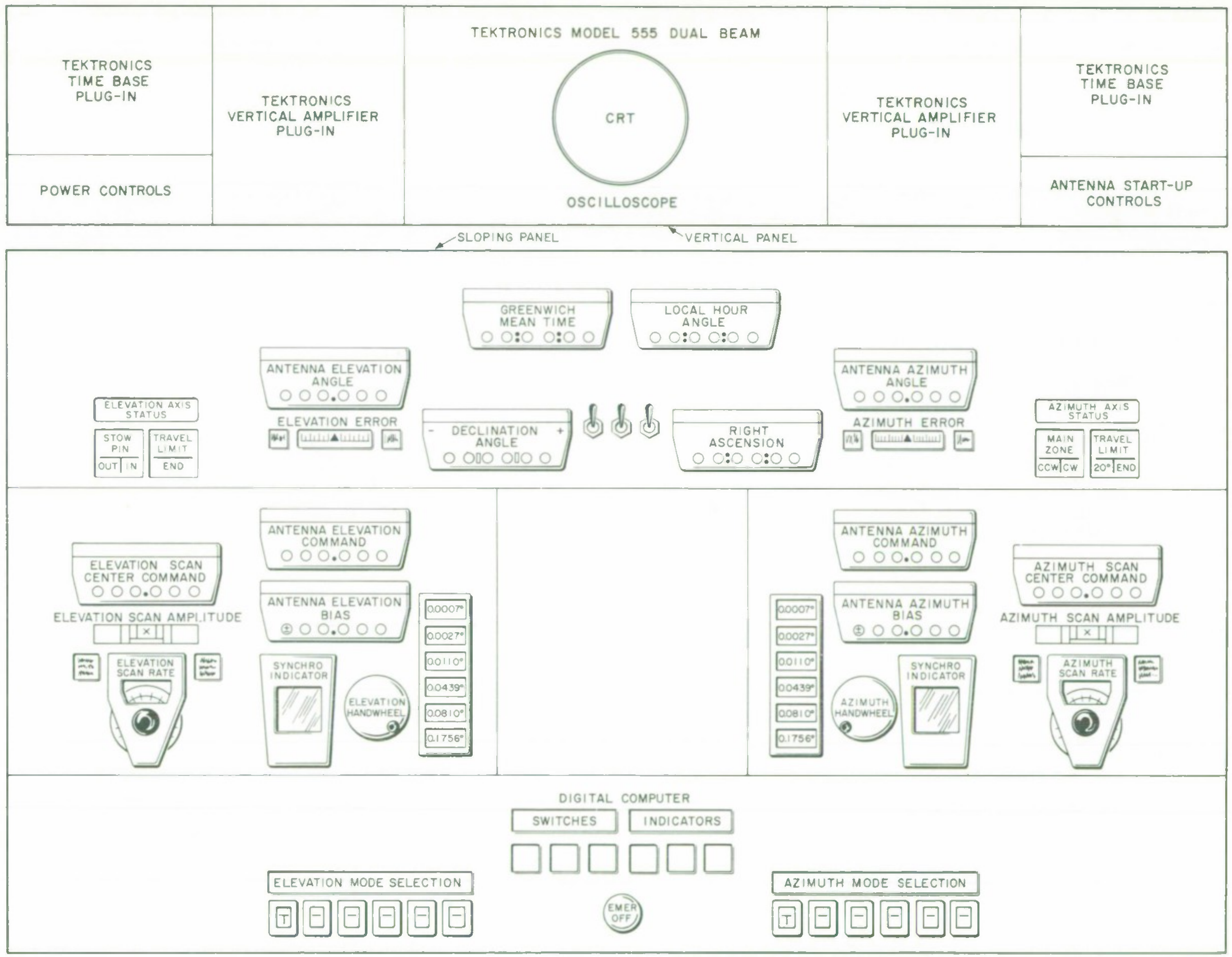

Fig. 2. Haystack pointing console: panel layout.

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13. ABSTRACT

This report describes the operation and organization of the digital equipment associated with the Univac 490 pointing computer at Haystack. All of the input/output equipment connected to the U490 is discussed with the major emphasis being placed on that equipment associated with pointing the antenna.

14. KEY WORDS

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